

## *Conducting an Accurate Utility Cost Analysis Based on UPS Efficiency*

## Introduction

Efficiency ratings of Uninterruptible Power Supplies (UPS) play an increasingly central role in the decisions of data center managers looking to cut energy costs. However, while these ratings remain an important factor for cost analysis, side-by-side comparisons often do not take into consideration the potential capacity effects on efficiency, that can mask the net efficiency of a UPS system.

## What UPS Efficiency Ratings Mean

The efficiency rating of a UPS — represented in percentage form — shows how much of the original incoming utility power is used to power your critical load versus how much is lost in the operation of the UPS. For example, a UPS that is 96 percent efficient passes 96 percent of the incoming utility power to the load, while a 94 percent efficient UPS passes 94 percent of the input power to the output. This also means that four or six percent of the power, respectively, represents losses, or wasted OPEX.

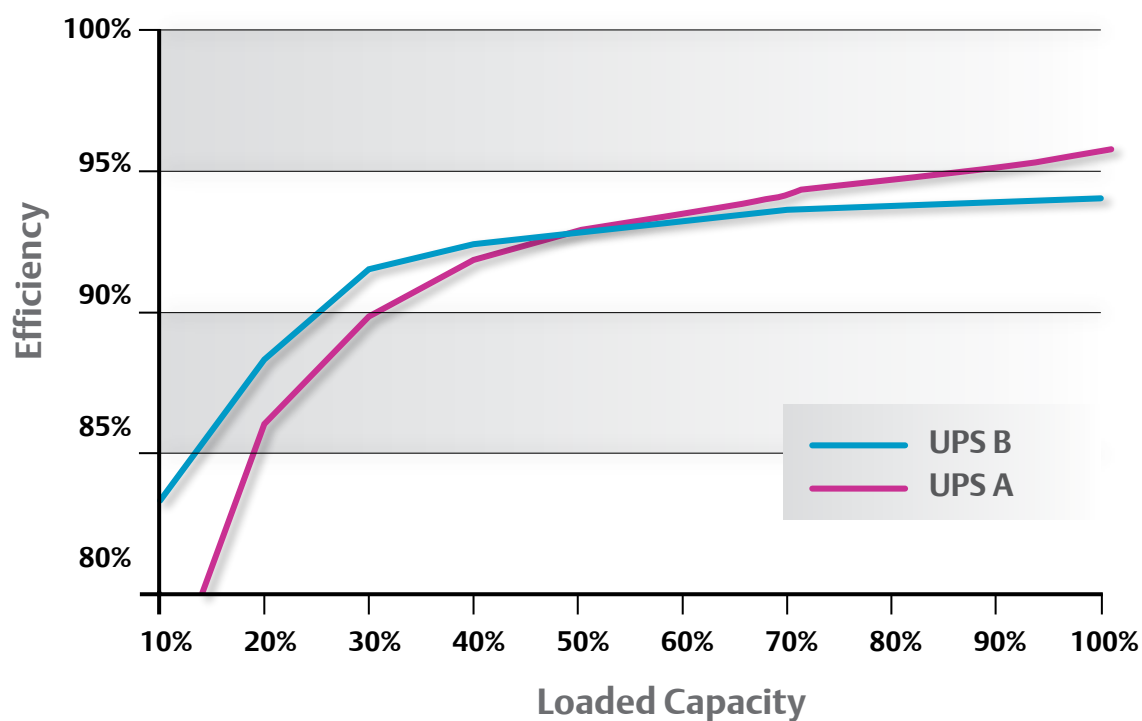
However, while a side-by-side comparison indicates that a 96 percent efficient UPS would yield greater energy savings, it is often overlooked that these “nameplate” ratings only represent full-load efficiency.

## How Capacity Utilization Impacts Efficiency

A UPS’s efficiency rating is not static. Rather, it follows a curve dictated primarily by power capacity percent utilization.. For example, when a 200 kVA UPS rated at 96 percent efficiency is operating at 20 percent capacity (40 kVA), only 85 percent of the input power will be passed along to the load. However, at full load under optimal operating conditions, the same UPS will leave only four percent of the input power as unusable OPEX.

A UPS’s efficiency ultimately is calculated by the UPS’s potential less fixed and proportional losses. While proportional losses — in the forms of heat-dissipation (“I<sup>2</sup>R” losses), are tied directly to increases in load, a UPS’s fixed losses (or “no-load” losses) remain constant independent of the amount of current running through the UPS. This means that fixed losses will have a more significant impact on efficiency when a UPS is evaluated at partial load.

To illustrate, consider the efficiency curves of two very different UPS systems (Fig. 1). UPS A is rated at 96 percent efficiency and UPS B is rated at 94 percent efficiency.



**Figure 1.** Efficiency curves for two UPS systems are derived by measuring the difference between utility and IT loads from zero to 100 percent capacity.

At full capacity, UPS A with 96 percent efficiency would be the logical choice when deciding which of the two units is more efficient, but the story is different when compared at different operating capacities (Fig. 2). At capacities under 50 percent, the “less efficient” UPS actually is more efficient than the “96 percent efficient” UPS.

	30% capacity	50% capacity	100% capacity
UPS A “98% efficient”	89.5% efficient	92.0% efficient	96% efficient
UPS B “94% efficient”	91.5% efficient	92.5% efficient	94% efficient

**Figure 2. Fixed losses for UPS A are slightly higher than those for UPS B, making UPS B the ideal choice for operating at loads below 50 percent.**

Considering that utilization of a UPS at less than half capacity is standard procedure when operating redundant UPS systems or when anticipating infrastructure expansion, comparison of these curves emphasizes the need to evaluate the efficiency of the UPS based on real-life operating scenarios. This means developing utility cost models that accurately reflect real-life operations rather than nameplate rating alone.

## How to Develop a Basic Utility Cost Model

**Step 1:** Identify the expected Loaded Capacity of the UPS in kW.

**Step 2:** Identify the Output Efficiency at the Loaded Capacity.

**Step 3:** Determine your electricity cost.

**Step 4:** Calculate using the standard formula:

$$\frac{(\text{Cost Per kWh} \times \text{Annual Operating Hours}) \times (\text{UPS Rated Power kW} \times \text{Load Utilized})}{\text{UPS Efficiency at Load Utilized}}$$

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Based on information gathered through the first four steps, a basic efficiency analysis example would look like this:

■ Loaded Capacity: 40%

■ Output Efficiency at the Loaded Capacity: 92%

■ Electricity Cost: 10 cents per kilowatt hour

■ The 750 kVA UPS has a power factor of .9 and a rated power rating of 675 kW

■ 8760 operating hours in a year (24 hours x 365 days)

For this specific example, the operating cost calculation would be:

$$\frac{(10 \text{ cents} \times 8760 \text{ hours}) \times (675 \text{ kW} \times 40\% \text{ capacity})}{(92\% \text{ efficiency})} = \$257,086 \text{ in utility operating costs for one year.}$$

## How UPS design impacts efficiency

Some UPS systems can achieve 99 percent efficiency by running on the UPS bypass. This mode of operation is called many things, including energy-saving mode, high-efficiency mode, eco-mode and sleep mode. It is essential to know if the efficiency rating you've been given is a bypass mode or if it represents your preferred operating mode.

First, ask the UPS manufacturer or representative if the efficiency rating incorporates some type of bypass operation. Then, consider whether or not the efficiency rating reflects your real-life operations and if you are going to run your UPS on the bypass?

- If “No,” get the real efficiency rating described in Step 2 of “How to Develop a Basic Utility Cost Model.”
- If “Yes,” consider how often you will be in this mode. Adjust your model to reflect this by calculating costs with bypass mode in operation (for the expected time duration) and without, then add the costs together to see what a full year's operation would look like.

Running on bypass is a good way to be more efficient, but it could compromise your data center's availability. Also, it is important to understand how the bypass operation is achieved. For example, you should consider if the static switch is utilized; whether the inverters are off or on; or what types of faults will be passed to your critical load.

In addition, there are other design decision that can severely compromise availability:

- Utilizing contactors and fuses instead of breakers
- Momentary duty static switch instead of continuous duty
- Elimination of the isolation transformers from the UPS



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## Conclusion

As we have demonstrated, UPS efficiency can fluctuate widely based on capacity utilization. In light of this fact, a thorough understanding of how partial-load configurations impact a UPS system's performance and efficiency is essential to achieving an accurate utility cost model. However, utility costs are only a single component of a Total Cost of Ownership analysis.

Any cost analysis must include maintenance, reliability, monitoring and, especially, the impact of UPS design on IT system availability. It also is critical to understand how a UPS is able to achieve its efficiency rating and what the impact is on availability. The high-efficiency UPS might not be the most fault-tolerant and might not be the best option for extremely critical environments.

By asking some questions and doing the math, you can find the UPS that is ideal for your specific operations.

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